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FAILURE ANALYSIS
OF
FLASHING LIGHTS
MICRO ELECTRONICS
P/N 209-B SN 7 & 12

(NASA-TM-109262) FAILURE ANALYSIS OF FLASHING LIGHTS. MICRO ELECTRONICS P/N 209-B SN 7 AND 12 (NASA) 14 p

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APPROVAL SHEET

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

I. INTRODUCTION

The Flashing Light is an electronic assembly used as a recovery aid on the Solid Rocket Booster and in the Frustum Location Aid. It is required to withstand the environments of prelaunch, launch, separation, water impact, recovery, and storage; and to functionally operate for 280 hours after splashdown.

Flashing Lights SN7 and SN12 were selected randomly from a group of six lights to be the qualification units. These lights had previously undergone formal acceptance testing at the vendor (Micro Electronics Inc.).

The original acceptance tests consisted of functional, random vibration (16.2 Grms and 8.1 Grms) and temperature cycling (1.5 cycles from -6.7°C to 60°C). The units were shipped to MSFC but had not been used when a problem was discovered with the capacitors and the seal. SN 7, SN 12, and other units were returned to the vendor for retrofit of the changes. After retrofit, the units successfully completed functional acceptance tests and were shipped to MSFC. Receiving functional tests were performed on the units and they were then committed to qualification testing.

After having been subjected to temperature cycle tests from -55°C to +73.9°C for five cycles, nonoperational, failure of the seals and a functional failure of SN7 were observed. The units were then sent to EC41 for failure analysis.

II. PURPOSE

The purpose of this analysis was to isolate the failure mechanism and determine the cause of failure of the flashing lights SN 7 and SN 12.

III. ANALYSIS

The light assemblies are shown in photographs 1 and 2 and consist of the following:

Housing:	Aluminum A356-T6
Base Plate:	6061-T651
Reflector:	ABS Plastic, Chrome Plated
Dome:	Clear Acrylic
Flash Tube:	Glass, Xenon filled
Electronics:	Printed Circuit Assembly
Potting:	Silicone Dow Corning, #184

The dome is attached to the aluminum housing with an adhesive as shown in Figure 1. The adhesive material is a polyurethane (Furane X-87718-A/B).

The lights are assembled as follows: The dome-housing assembly is inverted, the reflector and flash tube are positioned in the dome and potted using the silicone material and cured at room temperature. Next the printed circuit assembly is put in place, attached electrically to the flash tube and secured by screws to the housing. The remaining cavity is then filled with the silicone material and cured at room temperature. The base plate is assembled to the housing with screws and sealed.

A failure analysis plan (Attachment 1) was developed. Upon receipt of the lights in failure analysis, they were photographed, documented, and subjected to functional tests. SN 7 did not function electrically. SN 12 passed all functional tests. The observed failed conditions are shown in photographs 3 through 8. The dome-to-housing seal was fractured on both units approximately 270° around the circumference. The dome had lifted approximately 1/4 inch from its original position on both lights. The fractured areas were analyzed by the M&P materials specialist. It was determined that the sealant material (polyurethane) had been sheared by stress.

The dome was removed by drilling a small hole in the top and applying air pressure. After removal of the dome, on SN 7, it was observed that the flash tube was ruptured at the point where the electrodes enter the glass as shown in photographs 9 and 10. This rupture occurred as a result of the movement created when the dome-to-housing seal fractured. To verify that the rupture of the flash tube was the cause of the functional failure, in SN 7, an external flash tube was connected and functional operation of the light was verified. It was also observed that the adhesion of the polyurethane to the acrylic dome was inadequate.

The potted assembly was completely removed from the housing and inspected. No other anomalies were observed.

The acrylic dome was removed from SN 12 using the same procedure. A lack of adhesion of the polyurethane to the acrylic was evident. No rupturing of the flash tube or any other anomalies were observed in this unit. The seal fracture was the same as in SN 7.

IV. CONCLUSIONS

The failures of the Flashing Lights were caused by thermal expansion of the silicone potting material at high temperature. The thermal expansion coefficient of the silicone material is 300μ in. /in./°C. The aluminum housing thermal coefficient is 16μ in. /in. /°C. The acrylic dome has a coefficient of 80μ in. /in. /°C.

Because of the difference in expansion coefficients, internal pressures were generated which exceeded the strength of the dome-to-housing seal, causing failure. The movement of the material after seal fracture created excessive stresses on the flash tube causing glass rupture in SN 7.

The relative position of the flash tube electrodes to the fractured seal area accounts for SN 12 flash tube not being ruptured. It can be seen in the photographs that because of the location of the seal fracture in SN 12, the stresses on the electrodes at glass entrance were primarily tensile, whereas in SN 7 these stresses were in bending.

The adhesion of the polyurethane to the acrylic dome was inadequate in both SN 7 and SN 12.

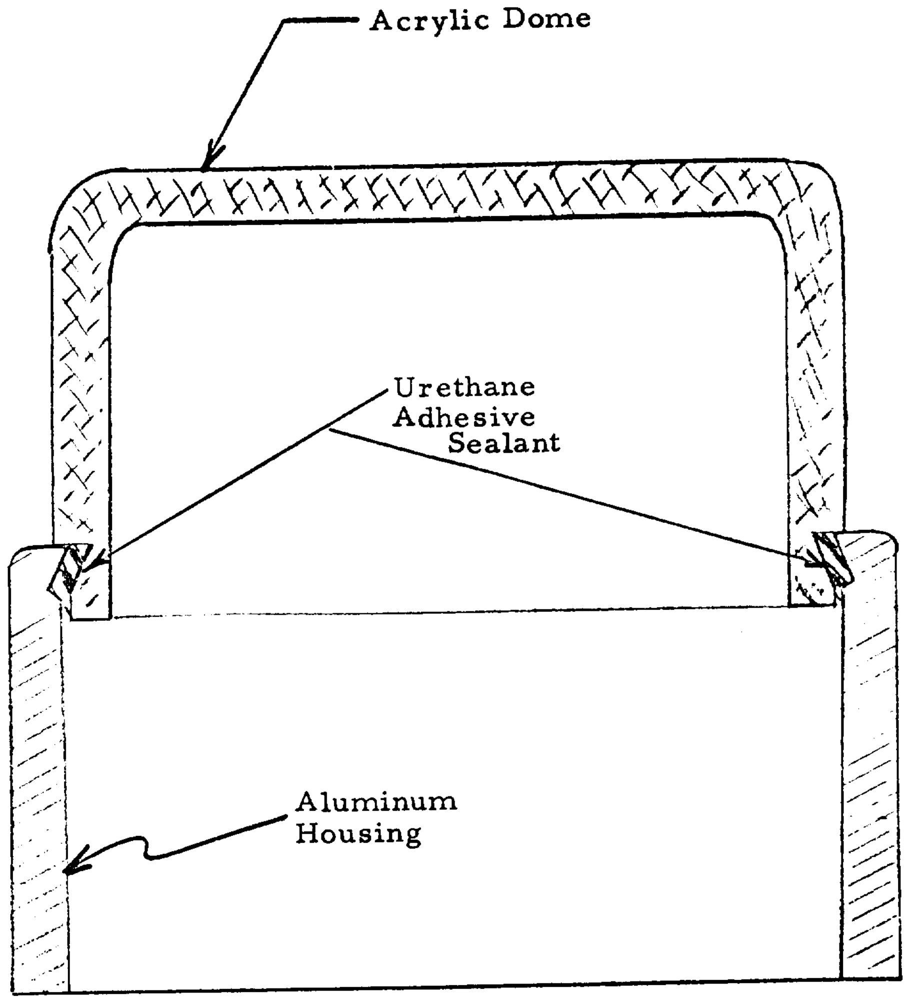
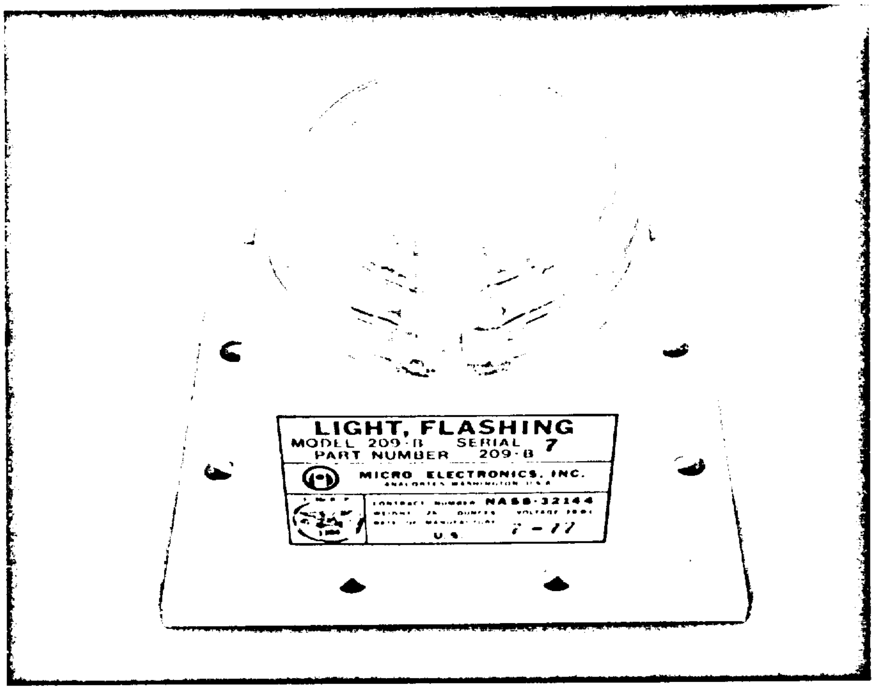
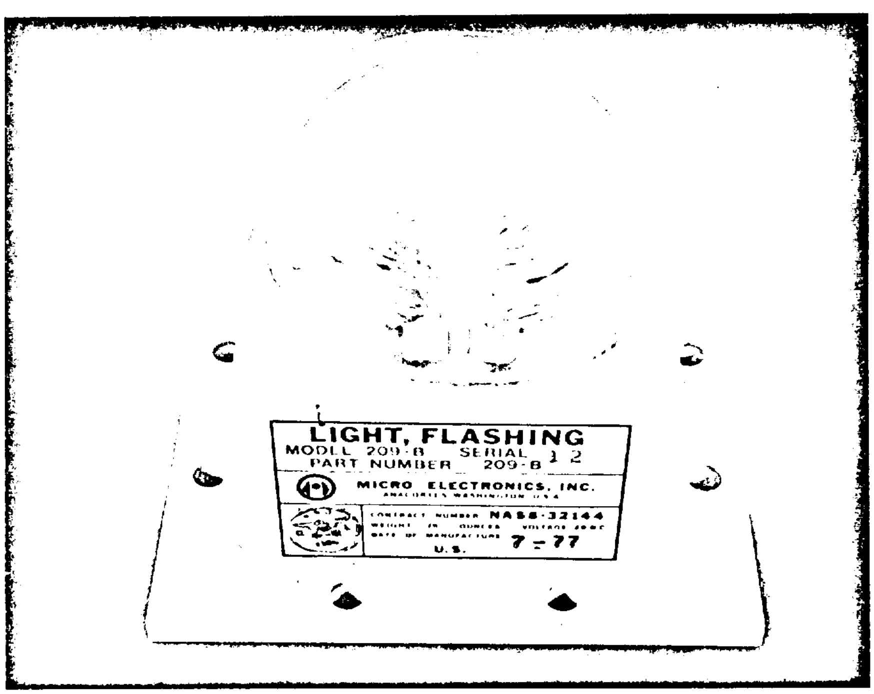


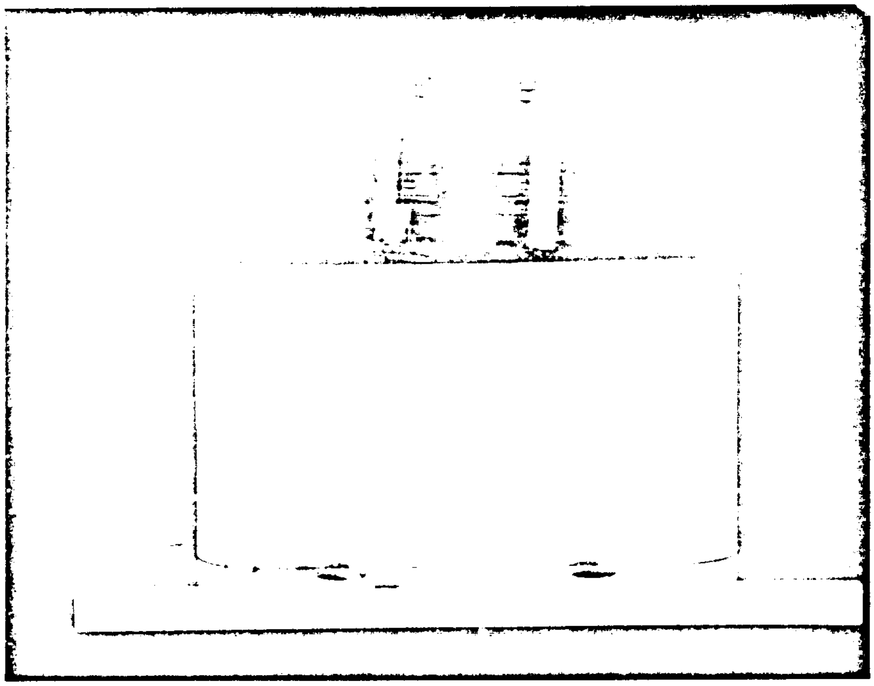
Figure 1: Dome-Housing Assy.



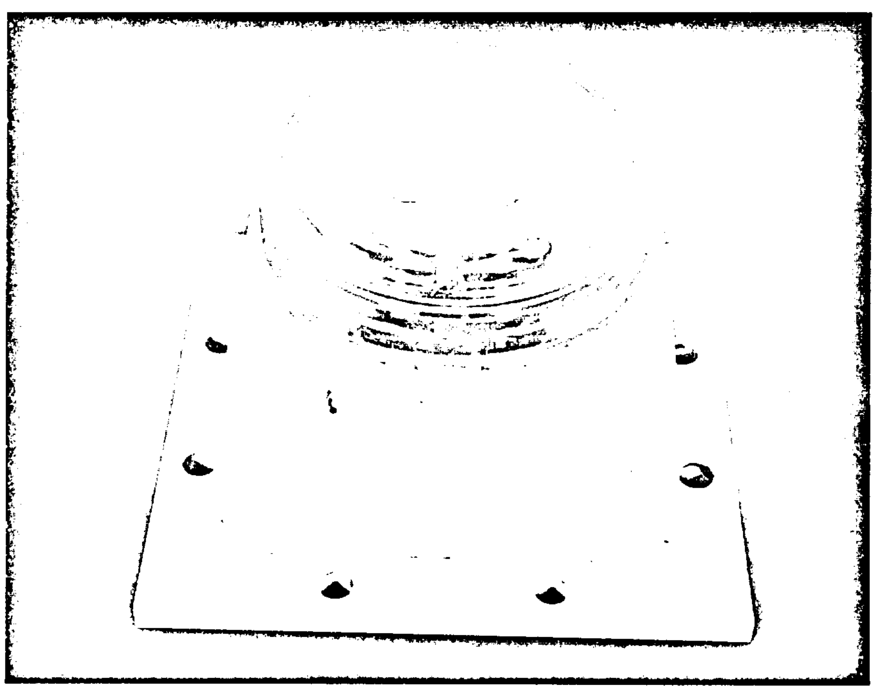
Photograph No. 1: Flashing Light SN 7



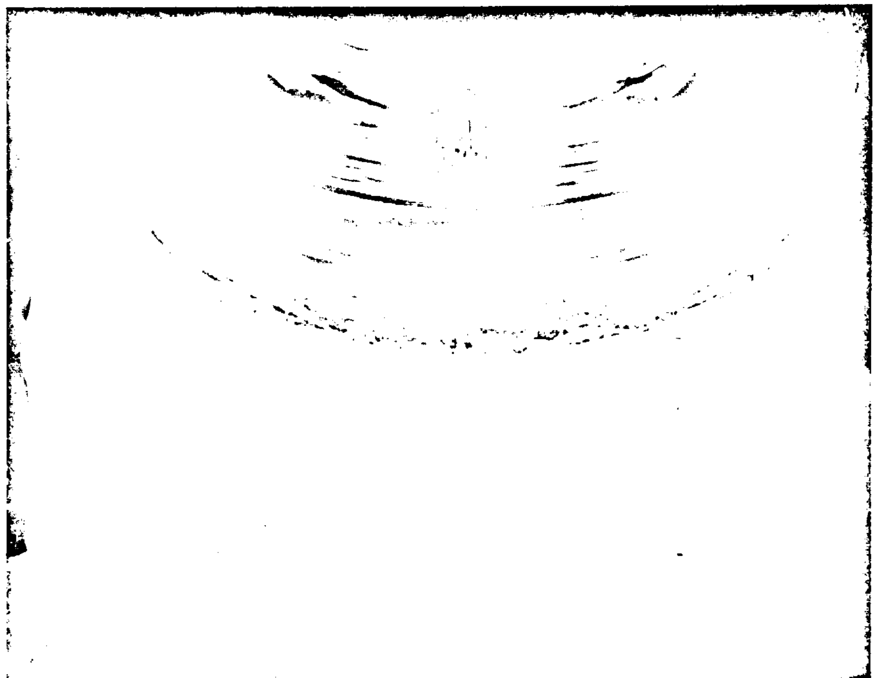
Photograph No. 2: Flashing Light SN 12



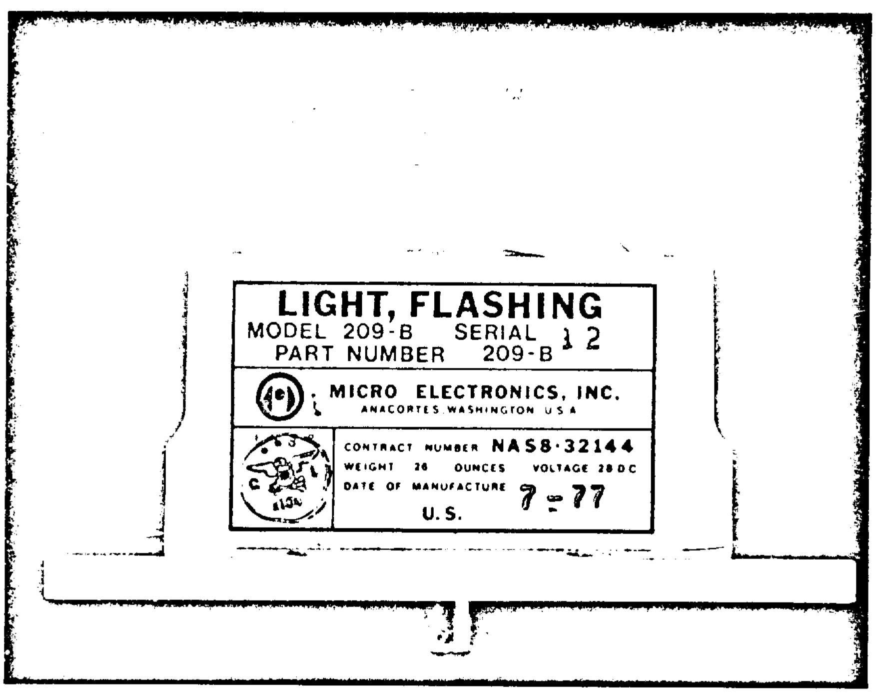
Photograph No. 3: Profile of Seal Fracture SN 7



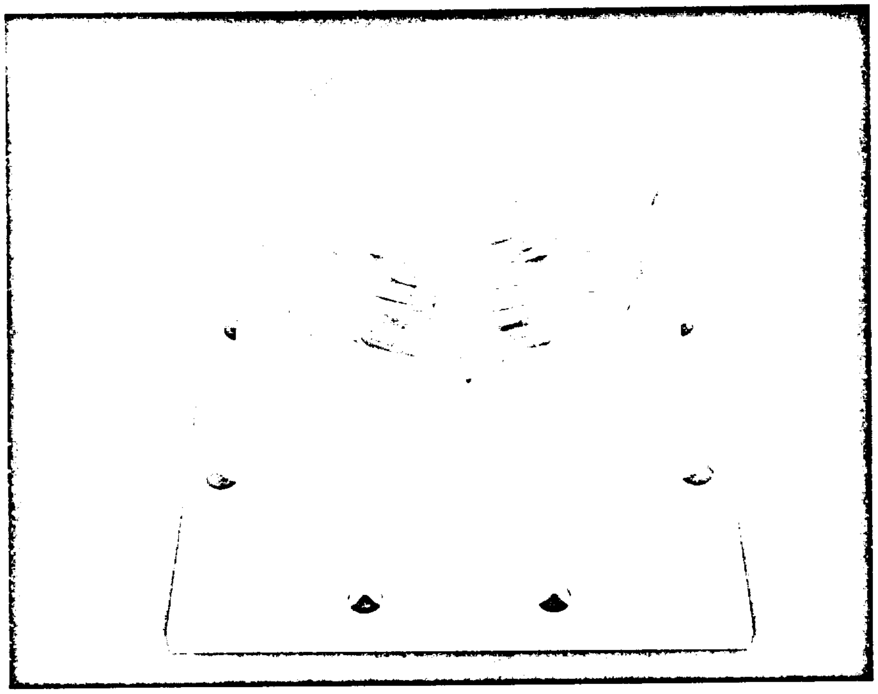
Photograph No. 4: Seal Fracture SN 7



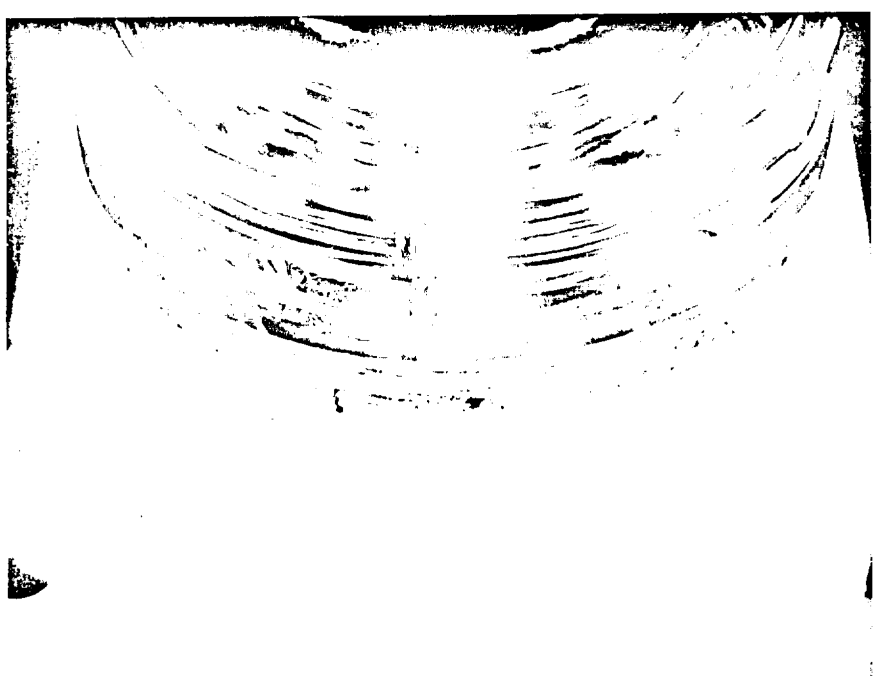
Photograph No. 5: Close-up of Seal Fracture SN 7



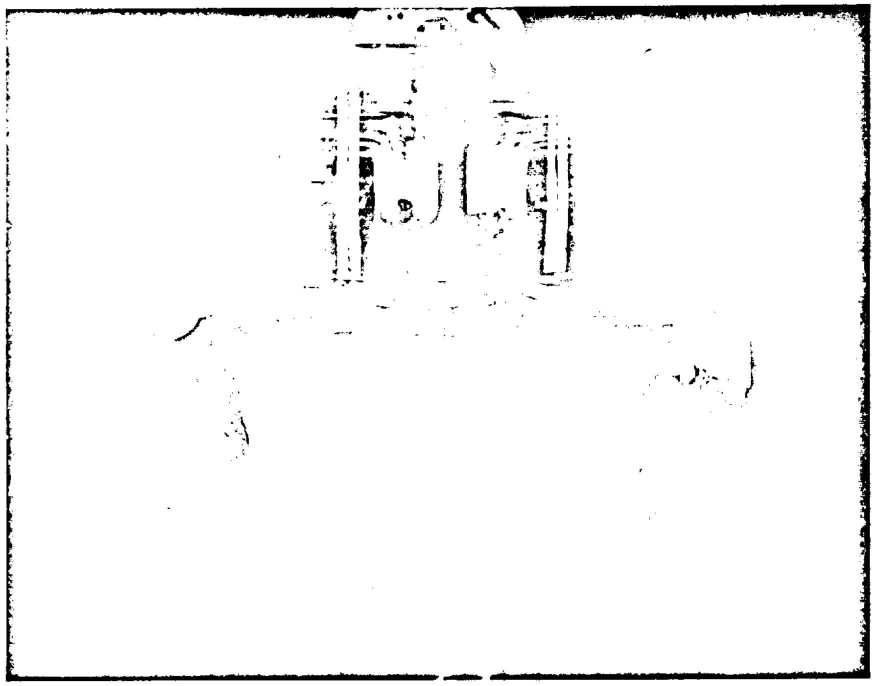
Photograph No. 6: Profile of Seal Fracture SN 12



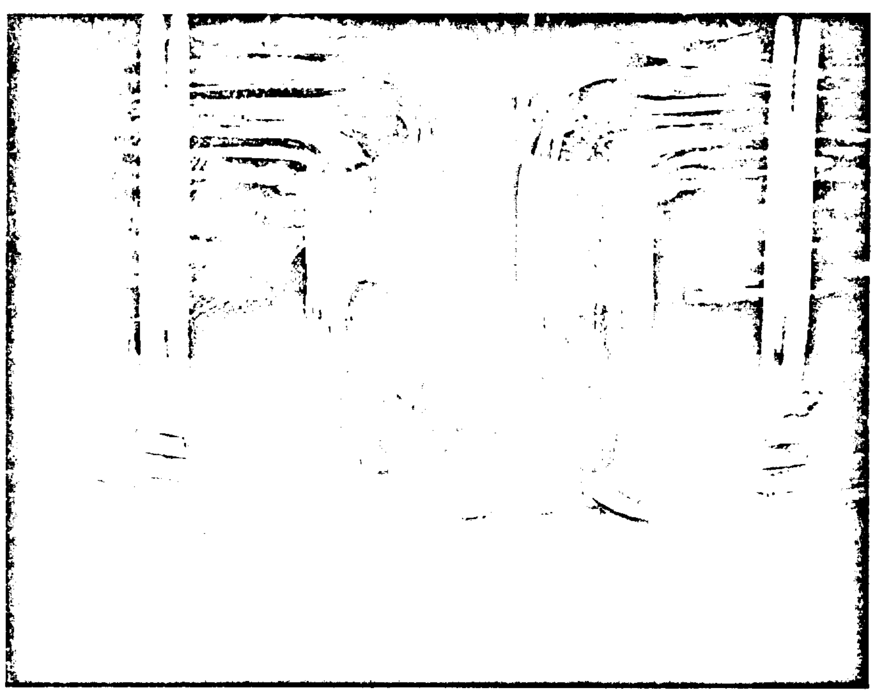
Photograph No. 7: Seal Fracture SN 12



Photograph No. 8: Close-up of Seal Fracture SN 12



Photograph No. 9: Potted Assembly SN 7



Photograph No. 10: Close-up of Potted Assembly
Showing Glass Tube Rupture

ATTACHMENT 1

FAILURE ANALYSIS PLAN FOR FLASHING LIGHTS

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1. Functionally Test Both Lights. Document results.
2. Try to functionally isolate electrical failure.
3. Photograph and Document physical condition of both lights.
4. Perform detailed analysis of fractured seal area.
   - -- Adequacy of bonding?
   - -- Fractured or de-bonded?
   - --Assess adequacy of the bonding material for the application?
5. Remove Acrylic Dome.
   - -- Photograph and analyze seal area on Dome and Housing.
   - -- Check physical dimensions.
6. Isolate Electrical Failure
   - -- Inspect xenon tube for fracture. Remove potting as necessary.
   - -- Inspect lead connections. Remove potting as necessary.
   - -- Photograph and document failure mechanism.
7. Determine Cause of Failure.
8. Identify Corrective Action
9. Identify Testing/Analysis accomplished to confirm corrective action.

H. Garrett

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